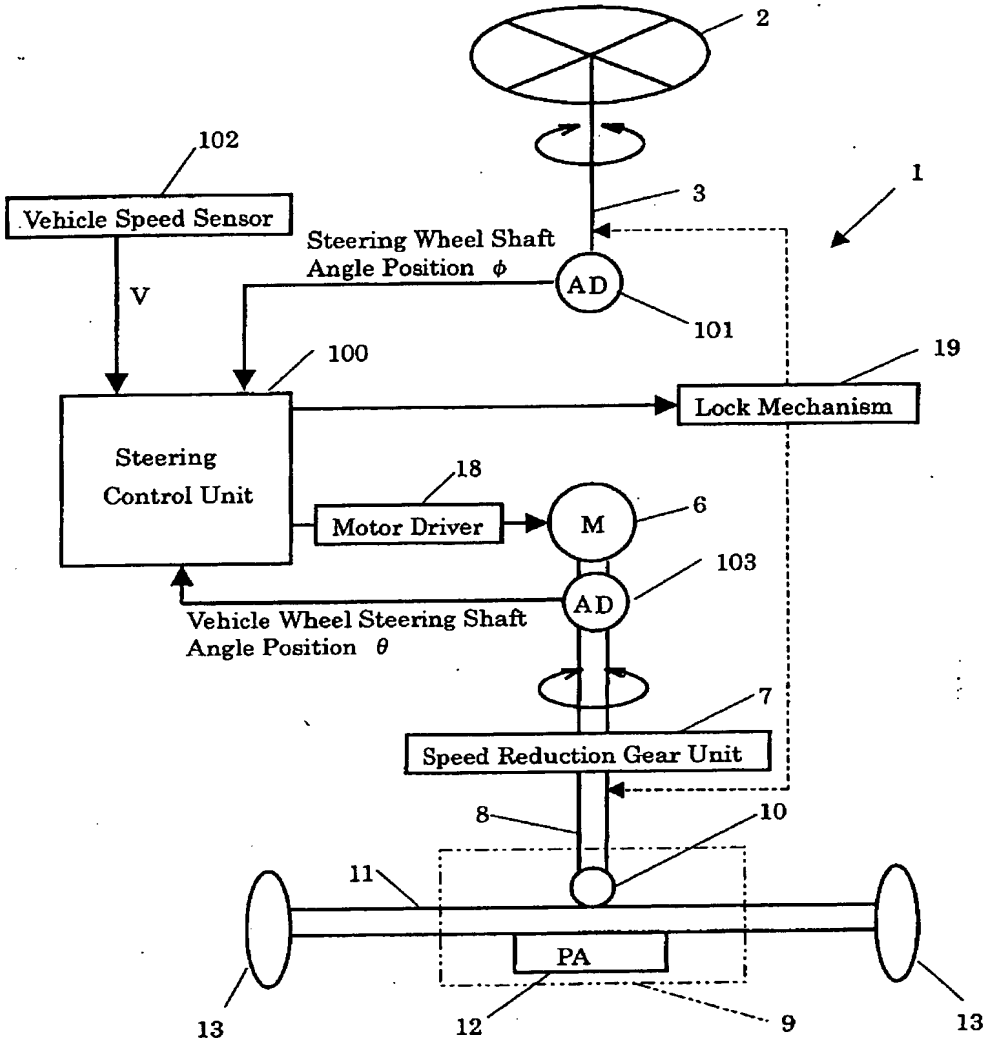

2
102
Vehicle Speed Sensor
1
3
Steering Wheel Shaft
Angle Position ϕ
AD
101
V
100
19
Lock Mechanism
Steering
Control Unit
18
Motor Driver
M
6
103
AD
Vehicle Wheel Steering Shaft
Angle Position θ
7
Speed Reduction Gear Unit
8
10
11
PA
13
12
9
13

FIG. 1

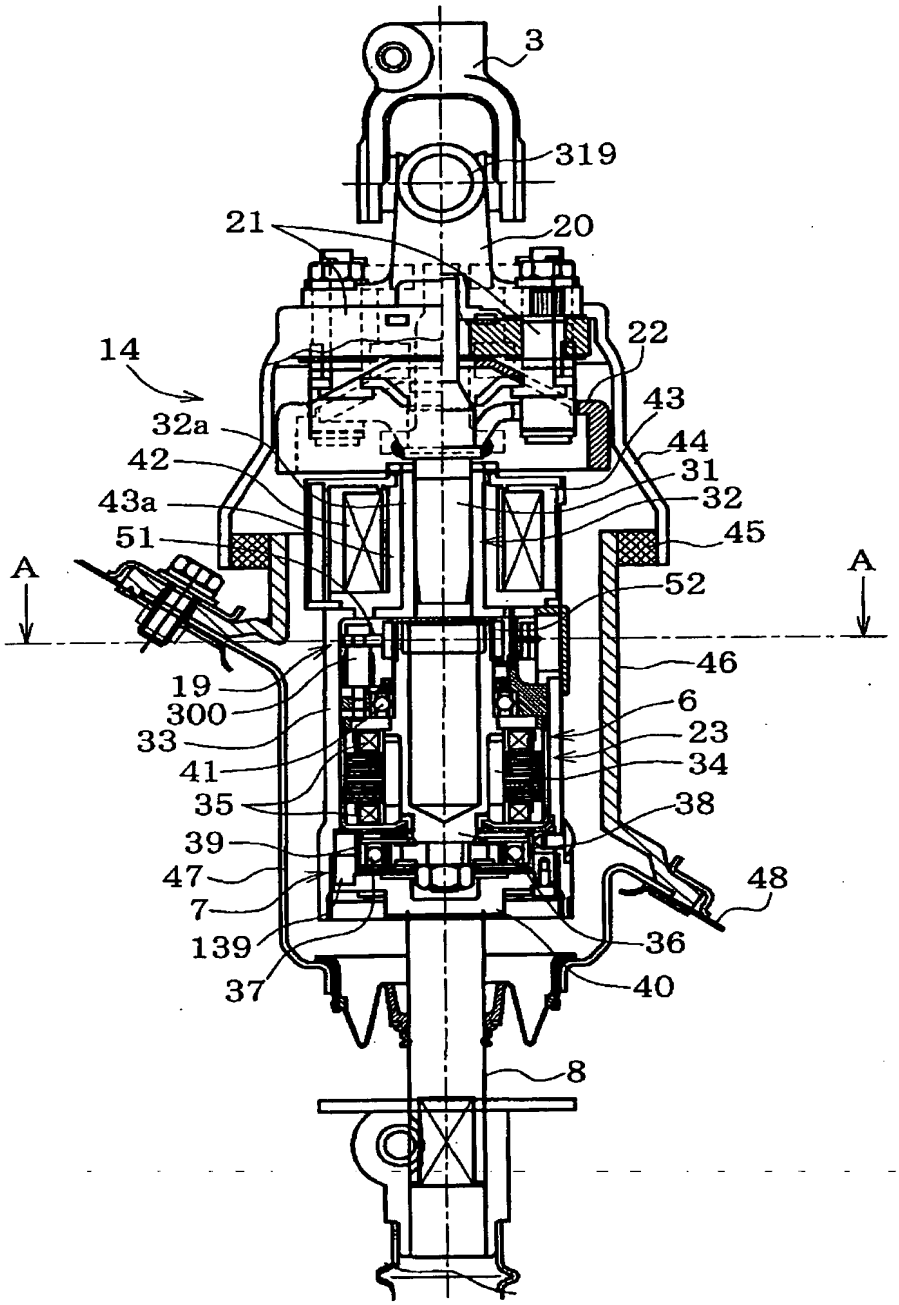

3
319
21
20
22
14
43
32a
44
42
31
43a
32
51
45
A
A
52
46
19
6
300
23
33
34
41
38
35
39
48
47
7
36
139
40
37
8

FIG. 2

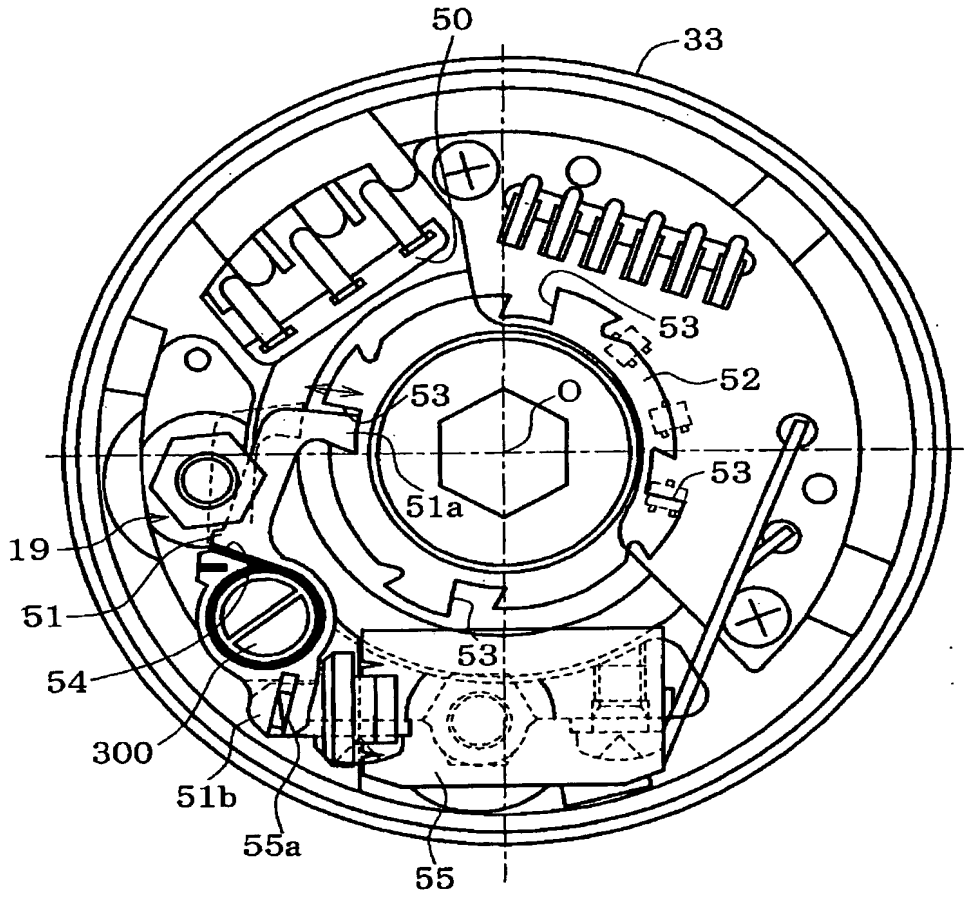
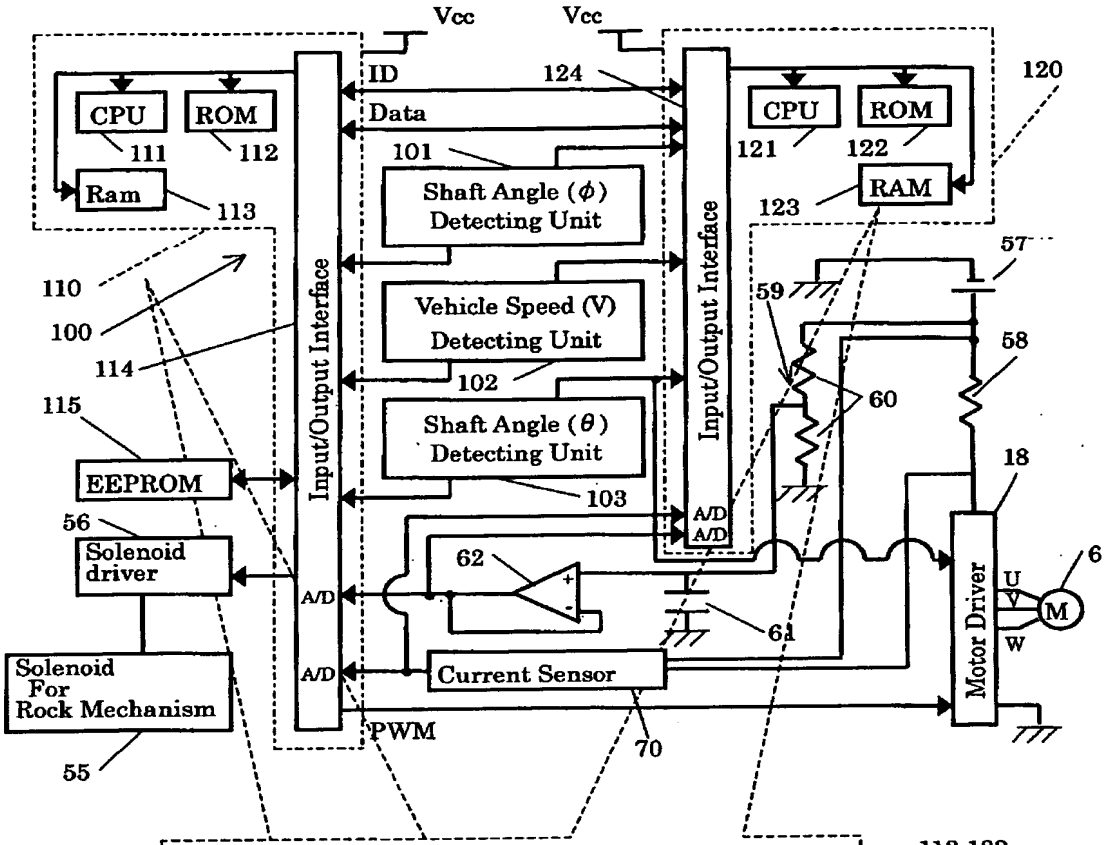


FIG. 3



113,123
Detected Vehicle Speed (V)
Counted Steering Wheel Shaft Angle Position (ϕ)
Calculated Steering Angle Conversion Ratio (α)
Calculated Target Vehicle Wheel Steering Angle Position (θ')
Counted Vehicle Wheel Steering Angle Position (θ)
Calculated Value $\Delta\theta$ ($=\theta'-\theta$)
Detected Power Supply Voltage (V_s)
Detected Duty Ratio (η)
Detected Current (I_s)
Flag for Selecting First or Second PWM Control

FIG. 4

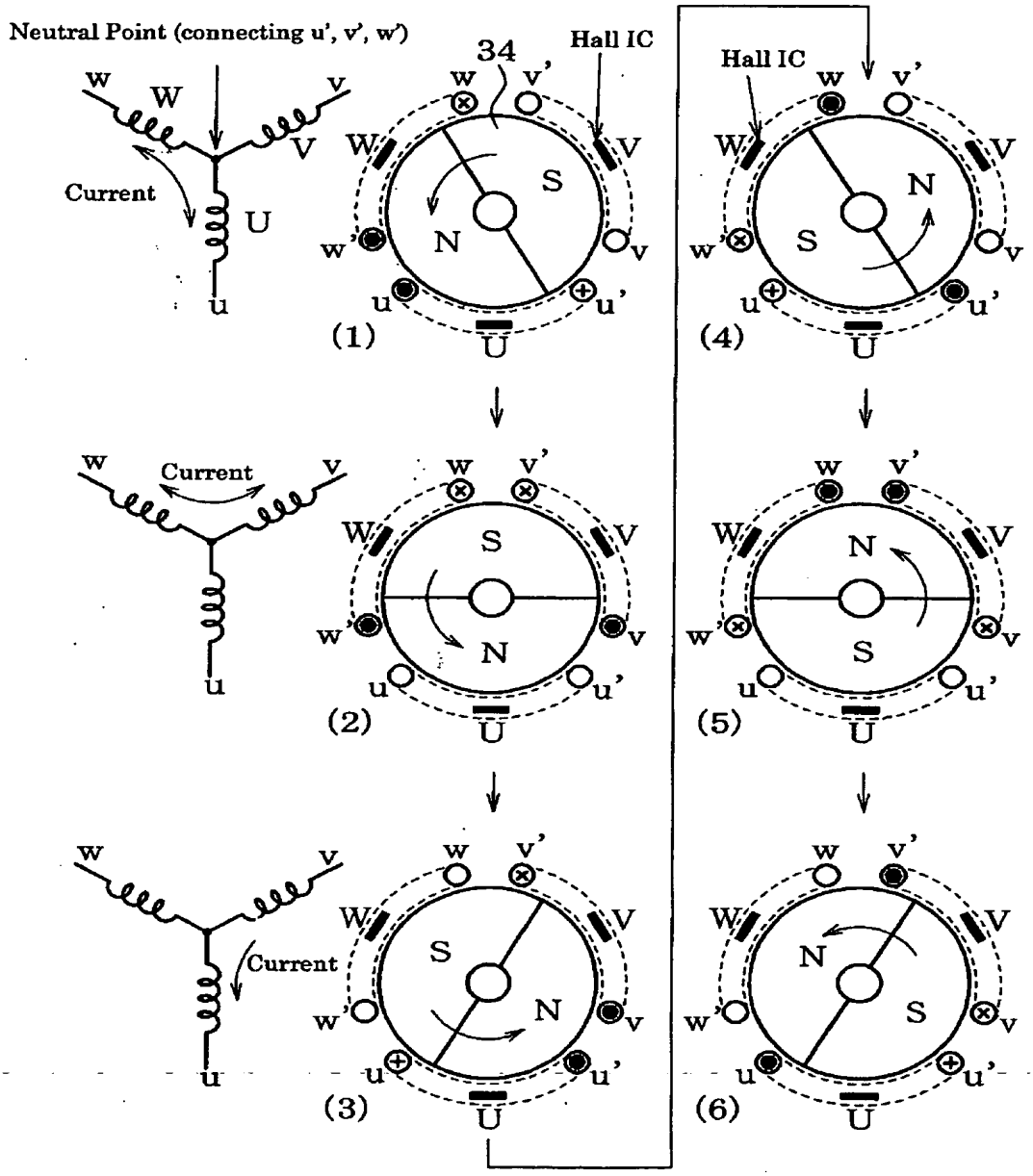


FIG. 5

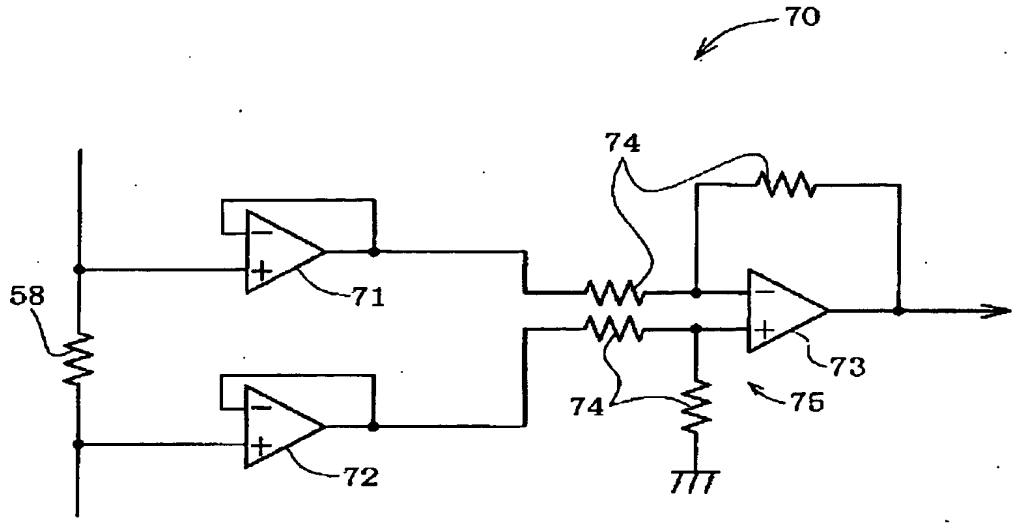

70
74
58
71
73
74
75
72

FIG. 6

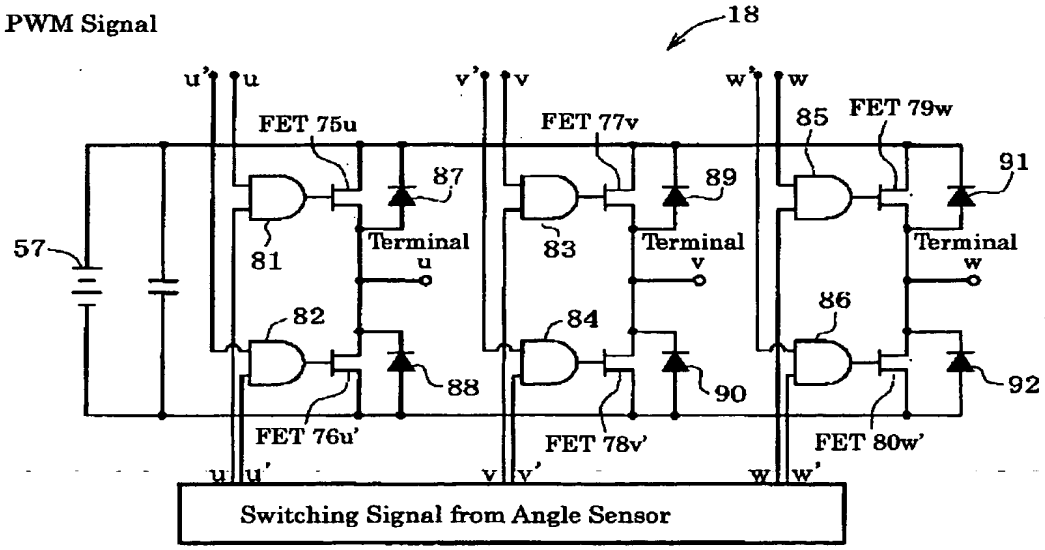

PWM Signal
18
u'
u
v'
v
w'
w
FET 75u
FET 77v
85
FET 79w
87
89
91
57
81
Terminal u
83
Terminal v
Terminal w
82
84
86
88
90
92
FET 76u'
FET 78v'
FET 80w'
u
u'
v
v'
w
w'
Switching Signal from Angle Sensor

FIG. 7

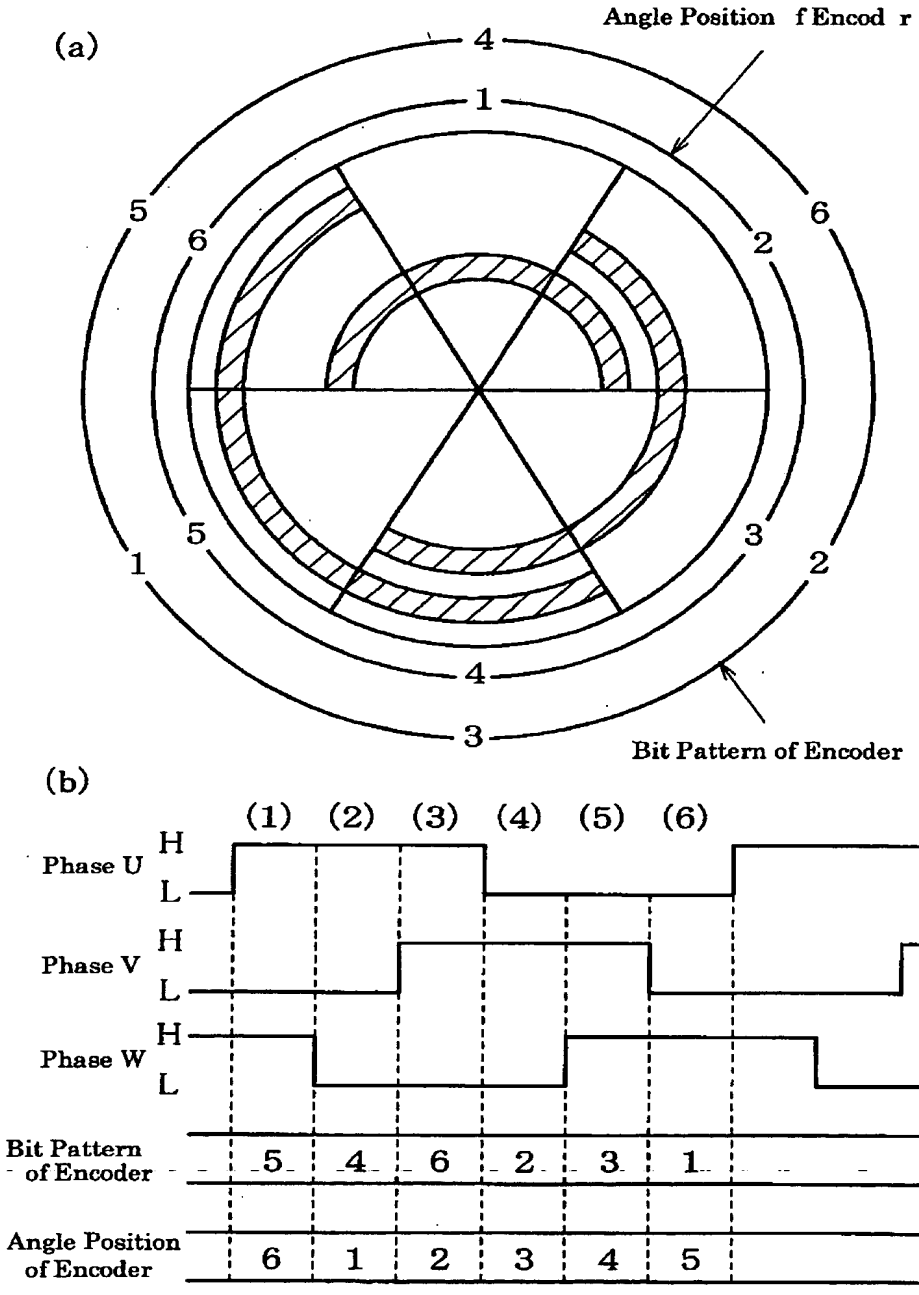

(a)
Angle Position f Encod r
Bit Pattern of Encoder
(b)
(1) (2) (3) (4) (5) (6)
Phase U
Phase V
Phase W
H
L
Bit Pattern of Encoder
5 4 6 2 3 1
Angle Position of Encoder
6 1 2 3 4 5

FIG. 8

130

Vehicle Speed (V)	V_1	V_2	V_3	.....	V_n
Steering Angle Conversion Ratio (α)	α_1	α_2	α_3		α_n

$\alpha = \theta / \phi$ ϕ : Steering wheel shaft angle position

θ : Vehicle wheel steering shaft angle position

FIG. 9

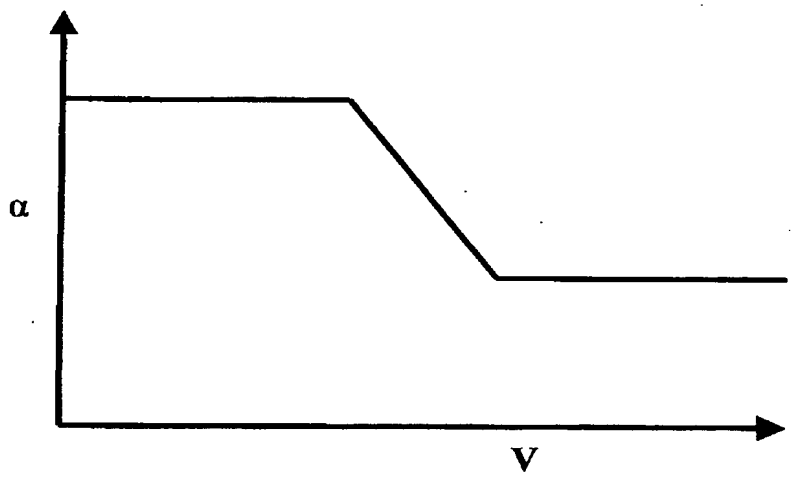


FIG. 10

131

Vs / Δθ	Vs_1	Vs_2	Vs_3	Vs_4	...	Vs_n
$\Delta\theta_1$	η_{11}	η_{12}	η_{13}	η_{14}	...	η_{1n}
$\Delta\theta_2$	η_{21}	η_{22}	η_{23}	η_{24}	...	η_{2n}
$\Delta\theta_3$	η_{31}	η_{32}	η_{33}	η_{34}	...	η_{3n}
$\Delta\theta_4$	η_{41}	η_{42}	η_{43}	η_{44}	...	η_{4n}
⋮	⋮	⋮	⋮	⋮	⋮	⋮
$\Delta\theta_m$	η_{m1}	η_{m2}	η_{m3}	η_{m4}	...	η_{mn}

η : Duty Ratio

$\Delta\theta = \theta' - \theta$

θ' : Target vehicle wheel steering shaft angle position

θ : Current vehicle wheel steering shaft angle position

FIG. 11

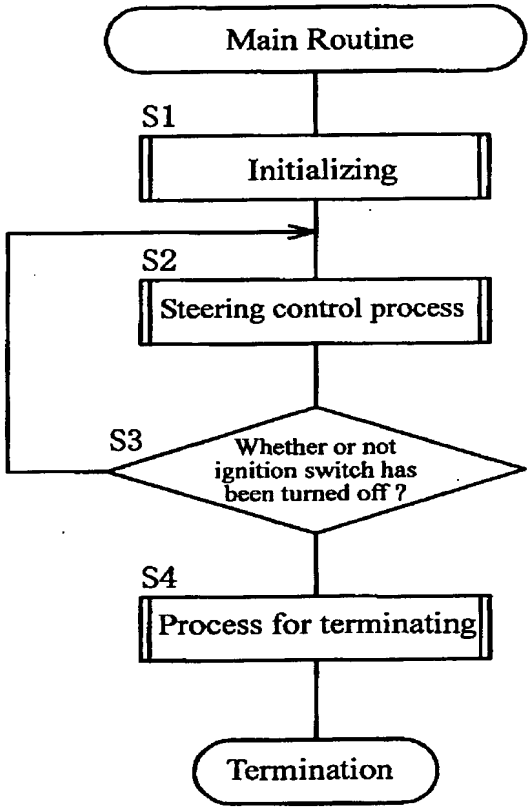

Main Routine
S1
Initializing
S2
Steering control process
S3
Whether or not ignition switch has been turned off ?
S4
Process for terminating
Termination

FIG. 12

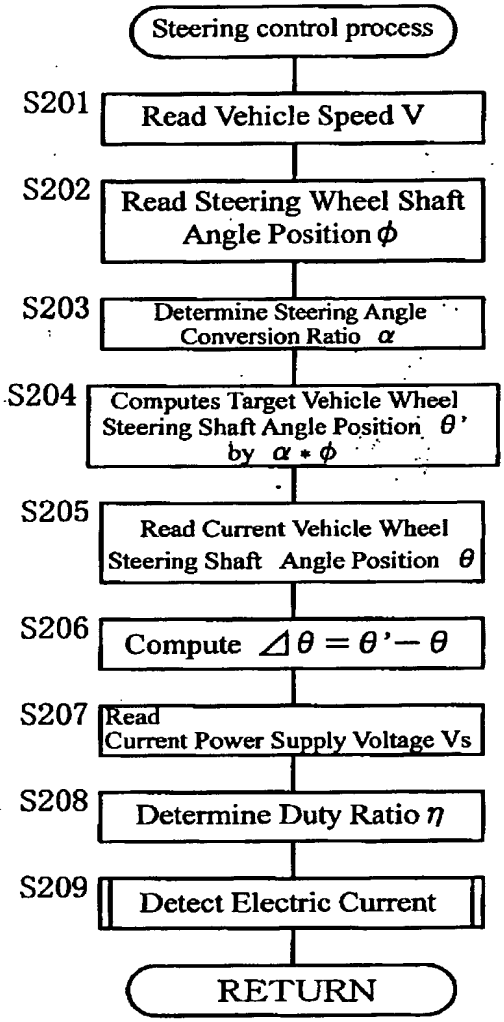

Steering control process
S201
Read Vehicle Speed V
S202
Read Steering Wheel Shaft Angle Position ϕ
S203
Determine Steering Angle Conversion Ratio α
S204
Computes Target Vehicle Wheel Steering Shaft Angle Position θ' by $\alpha * \phi$
S205
Read Current Vehicle Wheel Steering Shaft Angle Position θ
S206
Compute $\Delta\theta = \theta' - \theta$
S207
Read Current Power Supply Voltage Vs
S208
Determine Duty Ratio η
S209
Detect Electric Current
RETURN

FIG. 13

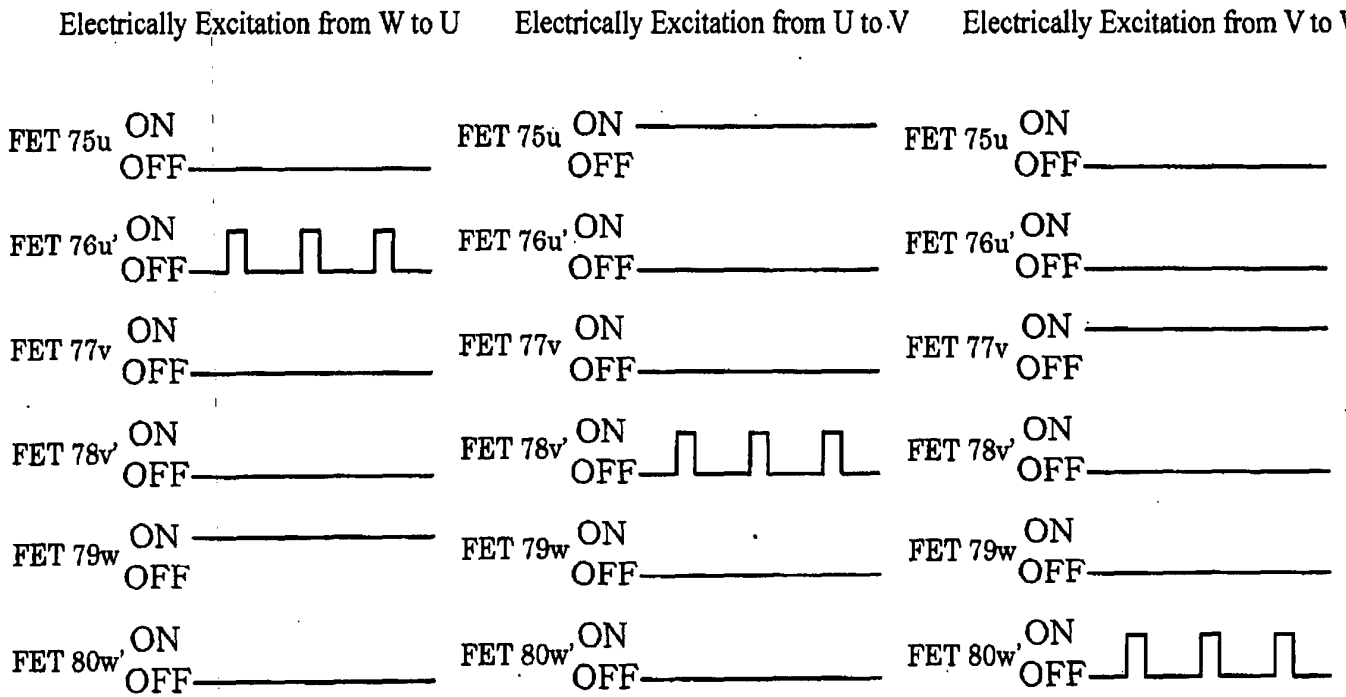

Electrically Excitation from W to U
Electrically Excitation from U to V
Electrically Excitation from V to W
FET 75u
FET 76u'
FET 77v
FET 78v'
FET 79w
FET 80w'
ON
OFF

FIG. 14

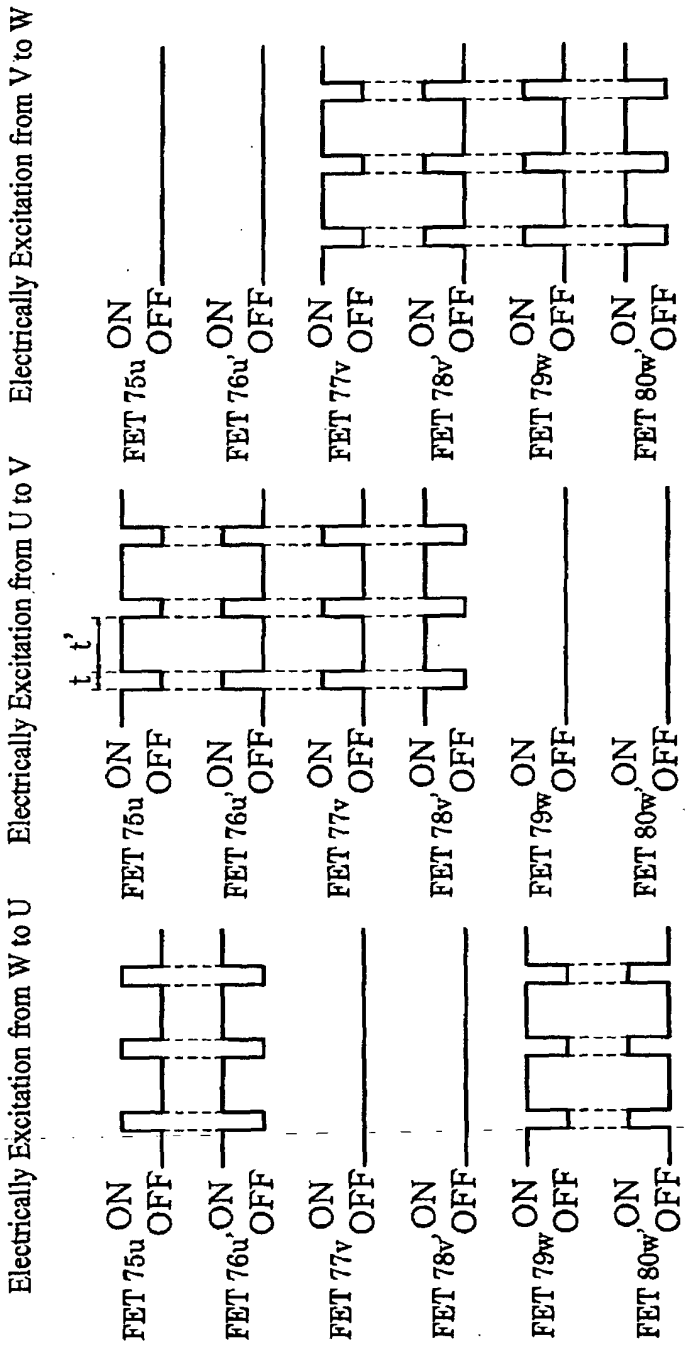

Electrically Excitation from W to U
Electrically Excitation from U to V
Electrically Excitation from V to W
t
t'
FET 75u
FET 76u'
FET 77v
FET 78v'
FET 79w
FET 80w'
ON
OFF

FIG. 15

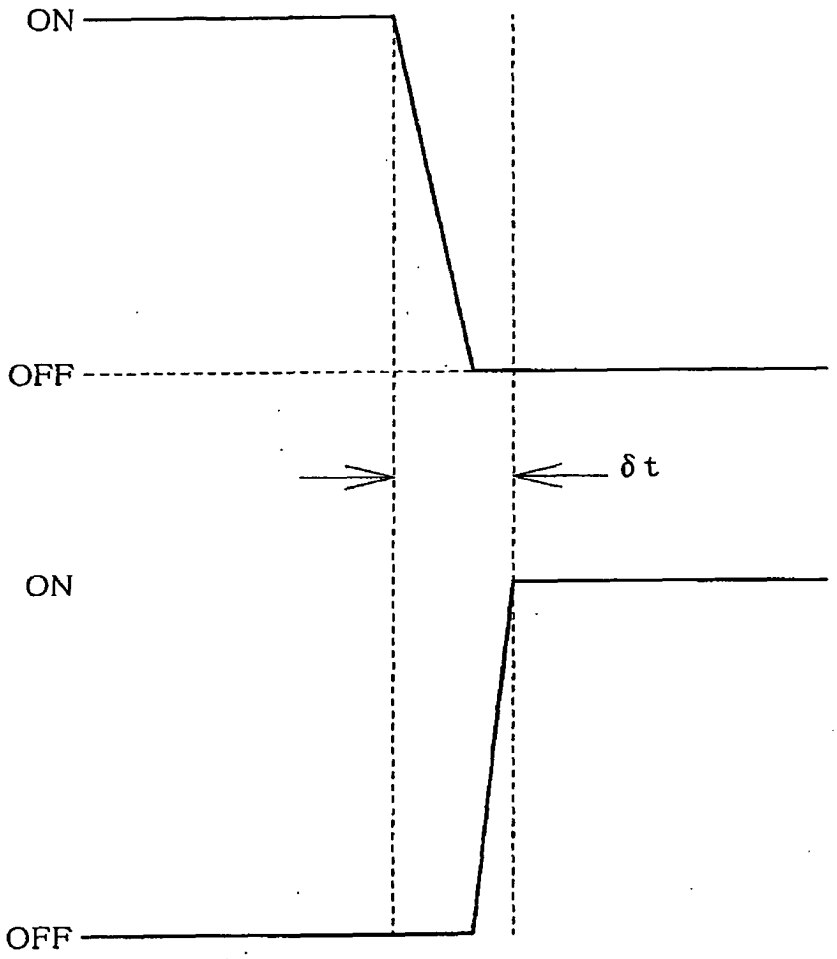


FIG. 16

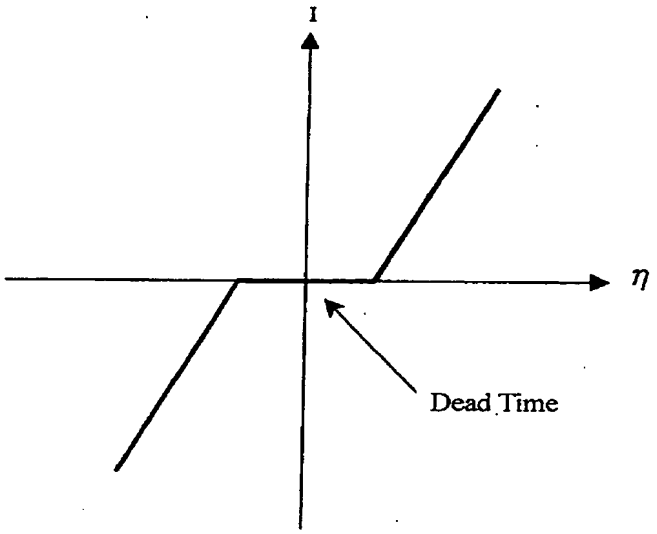


FIG. 17

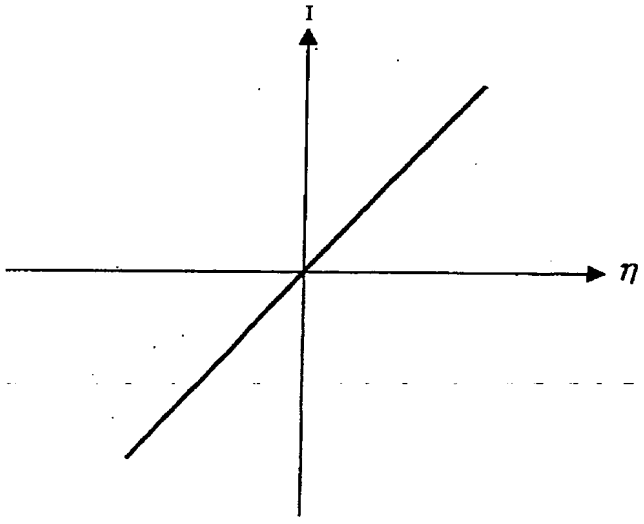


FIG. 18